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Dissolved Oxygen Depletion by the Roots of Conifer Seedlings During Root Soaking

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Introduction

Root soaking of bare-root nursery stock prior to outplanting is intended to reduce the moisture stress of coniferous seedlings or adjust their moisture content (Navratil et al. 1976, Navratil and Dye 1978). Soaking is recommended in at least two northern Ontario regions for all bare root stock whether overwinter stored, spring stored or fresh lifted (Anonymous 1971, 1983). Recommended soaking periods range from 4 to 48 hours but under some circumstances, soaking for 48 hours or more occurs. Lack of dissolved oxygen in the water during prolonged soaking has been identified as a potential problem (Anonymous 1982).

Free oxygen is important to root respiration although some species can cope with low oxygen levels or anaerobic conditions better than others (Hook and Brown 1973). In extreme cases, where oxygen is absent for 24 hours, roots of young seedlings can suffer irreparable damage (Leyton 1958).

The purpose of this note is to present some preliminary observations of the relationships between duration of root soaking, concentration of dissolved oxygen and potential impact on field performance of trees after outplanting.

Materials and Methods

Root soaking was done prior to outplanting in Flavell Township (47°57'N, 80°29'W) of 2+0 jack pine (Pinus banksiana Lamb.) and 1.5 + 1.5 black spruce (Picea mariana (Mill.) B.S.P.) from the Swastika Tree Nursery. Both spring lifted and overwinter stored stock of each species were used. Soaking was done in the plastic liners of the regular cardboard shipping boxes by filling them with lake water. The containers were protected from sun and wind by a large tarpaulin. For each species, 24 containers of trees were monitored. There were five containers of trees for each stock type (stored vs. fresh lifted) and water temperature (cold 0°C-1°C; warm 2.5°C-11°C) combination. In addition, there were 2 containers each with just warm and cold water as controls. The cold water temperature was maintained with the addition

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of ice. Trees were soaked for up to 48 hours. The concentration of dissolved oxygen was measured with a YSI 54ABP dissolved oxygen meter at regular intervals. Trees were removed from the bins at regular intervals for outplanting so the number of trees using oxygen from the water decreased with time.

In a laboratory trial, jack pine and black spruce seedlings were soaked for a prolonged period (up to 120 hours). Trees were removed after 8, 24, 48, 72, 96 and 120 hours of soaking and outplanted in a sandy clay-loam soil in a randomized complete block design with five trees per plot, three replications and six soaking times. The annual height increment after planting was measured at the end of the first growing season.

Results and Discussion

Dissolved oxygen (D.O.) levels of the water in which the roots were soaking decreased rapidly in the field trial (Fig. 1). Minimum D.O. levels were reached for all treatments and species within 24 hours and for the spring lifted stock, 90% of the total oxygen reduction occurred within 8 hours. The average D.O. levels did not go below 2.0 ppm in any treatment but the minimum D.O. concentration observed in an individual container was 0.6 ppm. Trees used oxygen at a significantly ($P<.05$) faster rate in warm water than cold and the spring lifted trees consumed oxygen faster in the first 8 hours than the fall lifted stock. In general, the black spruce utilized oxygen at a faster rate than jack pine (Fig. 1).

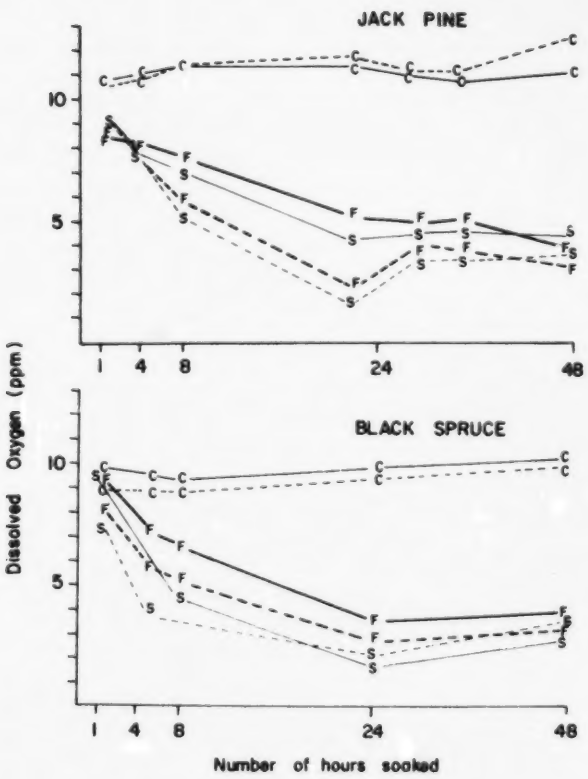

Figure 1 Dissolved oxygen content of control water (C) and of water used for soaking overwinter stored (F) and spring lifted (S) 1.5 + 1.5 black spruce and 2+0 jack pine. The water temperature was either maintained at 0°C-1°C (solid lines) or allowed to fluctuate with ambient temperature (dashed lines).

The amount of D.O. consumed during water soaking depends upon factors such as species, metabolic activity of the roots, water temperature and number of trees. The observed species differences in oxygen consumption were probably more a function of number of respiring roots than of species differences in oxygen demand. The total dry weight of jack pine roots was about 70% of the dry weight of the black spruce.

Dissolved oxygen consumption was greater in the laboratory trial, probably as a result of higher water and air temperatures and greater numbers of trees per unit of water. Mean D.O. was reduced to 1 ppm within 8 hours and to 0.5 ppm in 48 hours by black spruce (minimum dissolved oxygen levels in individual bins reached 0.1 ppm in 3 bins and levels of 0.2 ppm were common). Jack pine used D.O. at a much reduced rate, reaching 1.0 ppm after 24 hours and 0.7 ppm after 48 hours (Fig. 2).

The first year current annual height increment (Fig. 2) was significantly ($P<.05$) smaller on the soaked trees than the ones planted directly from the bag. This difference was most evident after 48 hours of soaking. This would indicate that soaking for more than 48 hours was detrimental to field performance as has been suggested elsewhere for red pine (Racey and Hutchison 1983).

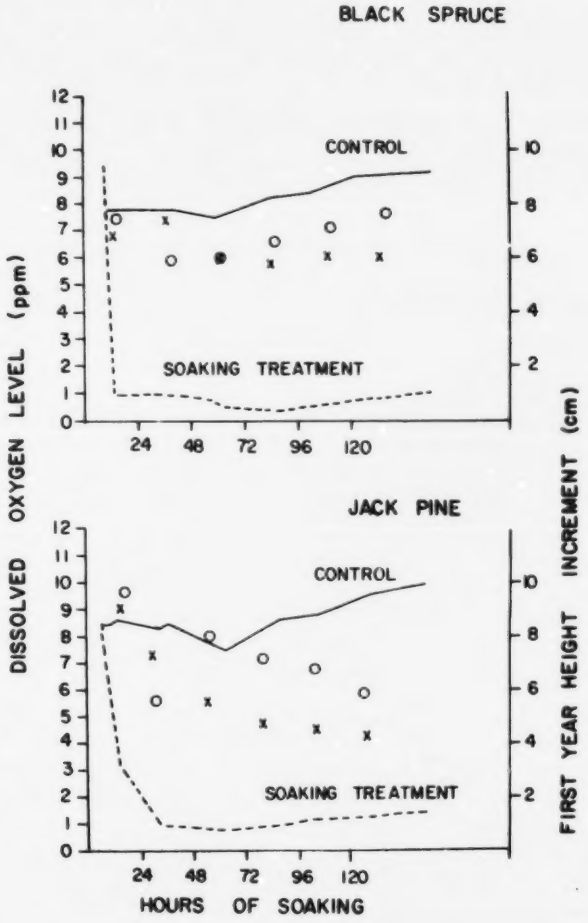

Figure 2 Dissolved oxygen content of control (solid lines) and soaking water (dashed lines) for 2+0 jack pine and 1.5 + 1.5 black spruce soaked under laboratory conditions. The first year height increment of the outplanted soaked trees (X) was significantly ($P<.05$) smaller than for trees planted directly from the bag (O). Significant differences were determined using a paired comparisons test.

Conclusion

There is no evidence to suggest that soaking from 1 to 48 hours enhances or decreased seedling quality or field performance. However, soaking roots under oxygen-poor conditions should be avoided. It appears that most oxygen is depleted after 8 hours or less under operational conditions. Therefore, it is recommended that soaking be restricted to a maximum of 8 hours, if at all.

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